

ICU Management Protocol No. 7

LUNG PROTECTIVE STRATEGY

Principles:

1. Minimise atelectrauma (*under-recruitment injury*)
 - open up alveoli with recruitment manoeuvre
 - keep alveoli open (prevent de-recruitment) by applying optimal PEEP
2. Minimise volutrauma (*over-distension injury*)
 - keep plateau pressure < 30cm H₂O
 - use low tidal volume ventilation 6ml/kg IBW
3. Minimise O₂ toxicity
 - maintain F_iO₂ below 0.6
4. Accept physiologic target outside normal range
 - permissive hypercapnia
 - permissive hypoxemia

Recruitment manoeuvre

The patient must have relatively stable haemodynamics before a recruitment manoeuvre.

Choose one of the 2 options:

A. *Step-wise incremental PEEP*

- Patient may need to be paralysed during the manoeuvre
- Mode of ventilation: Pressure-controlled ventilation
- Driving pressure (inspiratory pressure) : 15 cm H₂O (up to 20 cm H₂O)
- Respiratory rate 10 - 12/min; I:E ratio 1:1; FiO₂ 1.0
- Begin with PEEP 15 cm H₂O. Ventilate for 5 - 6 breaths. Increase PEEP by 5 cm H₂O to 20 cm H₂O. Ventilate for 5 - 6 breaths. Reduce PEEP back to 15 cm H₂O and ventilate for 5 - 6 breaths.

- Repeat the process by increasing PEEP of 5 cm H₂O (PEEP 25 cm H₂O, then 30 cm H₂O and 35cm H₂O) each time till a peak pressure of 50 cm H₂O is achieved.
- At the end of the recruitment manoeuvre, perform an ABG with the following ventilatory settings PCV driving pressure 15 cm H₂O, RR 10/min, I:E 1:2, PEEP 20 cm H₂O and FiO₂ 1.0. P_aO₂ + P_aCO₂ > 400 mmHg suggests that there is less than 5% of the alveoli which are still collapsed.
- If unable to achieve the above, repeat the recruitment manoeuvre to a higher peak pressure (driving pressure + PEEP) e.g. 55 cm H₂O or 60 cm H₂O or even higher while maintaining the driving pressure at 15 cm H₂O.
- If still unsuccessful, consider repeating the recruitment manoeuvre in the prone position.
- Repeat recruitment manoeuvre after position change, circuit break, or deterioration of lung mechanics or P_aO₂.
- Monitor haemodynamics during manoeuvre. Terminate manoeuvre prematurely if:
 - S_pO₂ <85%
 - MAP < 60
 - HR < 60 or > increase more than 20% from baseline
 - New arrhythmia

B. PCV with PEEP method

- Sedate and paralyse the patient
- Pressure control ventilation
- FiO₂ 1.0
- I : E 1 : 1
- Rate 8-10/min
- PEEP 20 cm H₂O

- The peak inspiratory pressure is slowly increased to 50 - 55 cm H₂O.
- Ventilation at this peak pressure for about 2 minutes, after which the peak inspiratory pressure is lowered to 30-35 cm H₂O.

Optimal PEEP

- Search for the optimal PEEP follows a recruitment manoeuvre using the decremental PEEP technique.
- Set PEEP at 20 cmH₂O and reduce the PEEP gradually (1 cm H₂O every 5 min).
- 2 methods to determine closing pressure
 - A. *Best oxygenation method*

Perform ABG at each PEEP level. The PEEP level at which there is a reduction in PaO₂ of more than 10% from the previous indicates the collapse pressure. The optimal PEEP is set at 2 cm H₂O above the collapse pressure.
 - B. *Best compliance method*

Determine the compliance at each PEEP level. The PEEP level at which there is a marked decrease in compliance from the previous indicates the collapse pressure. The optimal PEEP is set at 2 cm H₂O above the collapse pressure.
- A new recruitment manoeuvre is performed at the optimal PEEP level.
- In extra-pulmonary ARDS, the optimal PEEP level is usually 16 - 18 cm H₂O in the initial phase and 8 -12 cm H₂O is enough after 1 -2 days.

Low tidal volume ventilation

- Calculate ideal body weight (IBW) of the patient.

$$\text{Male} = 50 + 0.91 [\text{height (cm)} - 152.4]$$

$$\text{Female} = 45.5 + 0.91 [\text{height (cm)} - 152.4]$$

- Mode: Pressure-controlled ventilation (preferred) or volume-controlled ventilation.
- Aim for tidal volume of 6ml/kg IBW while not exceeding plateau pressure (Pplat) of 30 cm H₂O. In PCV, plateau airway pressure is equivalent to peak airway pressure. If volume-controlled ventilation is used, the plateau pressure needs to be measured regularly e.g. 2 - 4 hourly.

If Pplat > 30 cm H₂O, decrease tidal volume by 1 ml/kg steps to 5 ml/kg or if necessary to 4 ml/kg IBW.

If breath stacking or severe dyspnoea occurs, tidal volume may be increased (not required) to 7 or 8 ml/kg IBW if Pplat remains ≤ 30 cm H₂O.

- Oxygenation: Aim for PaO₂ 55 - 80 mmHg or SpO₂ 88-95%
- Arterial pH: aim > 7.1

The respiratory rate may be increased to a maximum of 35 /min.

Infusion of intravenous NaHCO₃ 8.4% at 10 - 20 ml/hr may be considered.

References:

1. Amato MBP, Barbas CSV, Mediros DM. Effect of a protective-ventilation strategy on mortality in the acute respiratory distress syndrome. *N Engl J Med* 1998; 338:347-54
2. Gattinoni L, Pelosi P, Suter PM. Acute respiratory distress syndrome caused by pulmonary and extrapulmonary disease: different syndromes? *Am J Respir Crit Care Med* 1998; 158: 3-11
3. The Acute Respiratory Distress Syndrome Network. Ventilation with lower tidal volume as compared with traditional tidal volume for acute lung injury and the acute respiratory distress syndrome. *N Engl J Med* 342: 1301-08
4. Patient Centred Acute Care Training (PACT), European Society of Intensive Care. Respiratory failure. Oct 2002

Algorithm on lung recruitment manoeuvre using the step-wise incremental PEEP method

